PSS and Inventory Control: Provision in the UK manufacturing case study

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Abstract— Manufacturing companies are continually striving to sharpen their competitive advantage in many ways, such as product-service system (PSS) and inventory control. There are only a few published case studies of PSS in manufacturing contexts, and these tend to be implementations in large sized companies giving only limited knowledge related to complexity and performance of PSS due to issues of confidentiality. Inventory control has been researched for many years and has led to substantial improvements in performance across many industries. To date, very little research has been reported related to inventory control in product-service systems in manufacturing contexts. The research carried out for this paper involved collecting primary data from qualitative research conducted through a case study with a company in the United Kingdom and information from secondary sources. Analysis of the case study data has also identified areas for further research. This research will contribute to the existing body of knowledge by the creation of qualitative models which will provide understanding about types of PSS in manufacturing contexts.

Keywords—Product-Service System, Inventory Control, Case study

I. INTRODUCTION

Product-Service Systems (PSS) have been mentioned for many years in industrial trade journals, as various companies have adopted this approach to enhance their competitive advantage. However, for companies wishing to adopt PSS, its implementation is far from straightforward as PSS is an academically constructed term without a clear, universal definition of what exactly is or is not a PSS. In some contexts it is not even clear what is the distinction between a product and a service, as they can both be closely related to each other. It is therefore difficult for managers in manufacturing organisations to formulate appropriate plans to efficiently guide their companies in the adoption of the PSS paradigm. The implementation of inventory control systems in manufacturing has also been researched and documented for many years, and is well accepted as a means of enhancing competitive advantage. Inventory control is the process of determining the most appropriate amount of inventory that is required and planning for efficient inventory control requires questions such as how often inventory should be purchased and how much should be ordered, to be answered, so that effective inventory control mechanisms and procedures may be put into place. However, very little research has been reported on inventory control in the context of PSS although a change from the supply of products only, to the supply of combined products and services, can have substantial consequences on both the volumes and management of inventory. PSS may be understood as, product and service that coexist jointly in one system, whilst the service elements of the PSS offering in manufacturing companies can typically be divided into three main categories which are repair, maintenance and disposal.

In its widest scope, this research relates to any manufacture of a product where services of some type are offered or integrated with the product. A commonly occurring element in PSS descriptions is when the product and service are combined together to provide some reduction to the environmental impact resulting from the product's lifecycle. However, this research focuses instead on the manufacturing context, and in particular on the effects that the adoption of PSS has on inventory control. The aim of the research is to create a strategic approach or methodology to identify, analyse, and optimise inventory planning and control for PSS. Primarily, the study will concentrate on identifying, categorising and evaluating the system characteristics of typical PSS in manufacturing industry. Essentially, the study will include the development of underlying concepts involving; the manner of identifying key parameters; categorisation of the given parameters; and the methods of evaluating results. Basically, an understanding of system parameters is a guiding principle that governs most of the schemes in the adoption of PSS strategies. It is necessary to understand the effects that particular parameters have on the PSS as this knowledge will provide a basis for improving decision making for inventory planning. Understanding each critical parameter is crucial for the overall performance of the PSS and its inventory control systems. In particular, emphasis will be given to the identification of system parameters that have the most effect on profit, as well as on finding which combinations of values should result in maximum profit.

Although many researchers have studied PSS or inventory control in manufacturing, very little has been reported about the consequences of PSS on inventory control in manufacturing contexts. For this reason, qualitative research is required to provide better understanding of this subject. In the current research project, case studies are being carried out with companies who operate various types of PSS, and in particular a case study has been conducted with an SME in the United Kingdom, and this is reported in this paper. Clearly, PSS in manufacturing contexts has a broad coverage.

This research will be limited to the examination and discussion of the interactions between PSS and inventory control systems in manufacturing contexts. This research is mainly focused upon product-centric manufacturers who wish to transform their company to PSS manufacturing. The dominant interests within this research include uncertainty, service, product and PSS in manufacturing contexts. Other activities within the PSS that do not have any connection and integration between product and service inventory will be omitted in order to provide an initial focus for the methodology. PSS inventory consists of two subsystems: the product subsystem and the service subsystem and these are supplemented by a factory facility. Inventory control distributes financial responsibilities along the subsystems. PSS inventory needs to take account of the interrelations between customer and supplier. As a result, the subsystems' challenges are increased due to complexity and unpredictability deriving from the uncertainties in the management of relationships between the customers and suppliers. Variability is inherent in the subsystems, due to a range of uncertainties related to customer demand, customer usage of the products, lack of information etc and consequently there are difficulties and pressures for the suppliers trying to implement and operate a PSS system. This is of particular relevance to inventory control which is capital intensive and requires suitable financial coordination to succeed.

Scholars and practitioners in PSS are from multiple disciplines such as engineering design (cf. [1]; [2] and [3]), business management (cf. [4] and [5]) and information systems (cf. [6]) and [7]). As a result, cross-discipline research projects currently exist that emphasise different priorities and contribute in different ways to the PSS paradigm. PSS is a mature paradigm, with a diverse range of terminology. It is therefore essential to identify the relevant research in the manufacturing context and determine an appropriate starting point for future research. There are three elements of PSS which are product, service and system where a product is considered to be tangible, a service is intangible and a system provides interdependences and relations for product and service [8]. However, as an overview of the main characteristics of PSS which are very important for discussing PSS in manufacturing contexts is still missing, the work by [9] which provides the characteristics of PSS for an architecture context will be used:

i. The first specific characteristic is integration with the external factor customer. This characteristic is driven through a PSS service component and is not limited to the creation process only. The consumer in addition has to be integrated with the product to ensure customer oriented solutions. Consequently the event and creation processes of a PSS should be driven by internal (e.g. the product) and external factors (customers), whereas the roll-out of traditional products are mainly driven by internal factors.

ii. The second characteristic is individualization potential. The individualization potential is implied through the first characteristic but the amount of individualization is a consequence of the level of integration with each customer. The greater the degree of integration then the greater the level of individualization there will be.

iii. The third characteristic is the technical integration of a PSS product and service. The definition of technical integration refers to the functional connection of product and service. The more product-specific the service is then the greater the level integration. The status of the technical integration indicates the level of the interdependencies which exist between the involved product and service. The last characteristic is the output of third characteristics. The range of characteristics, caused through the heterogeneous constituent parts (product and service) and their interdependencies, results in the largest amount of complexity.

As PSS is an interdisciplinary field, many academics and practitioners have conceptualised and generated methods and models of PSS according to their work areas. Most of the research in PSS is applying single and confidential case study approaches and collaborations with industry. Therefore, it is difficult to identify the guidelines, tools and the methods and model techniques involved may not be applicable to replicate and evaluate in practice. The published work on PSS does not discuss in depth the adoptability of PSS methodologies to other fields and its limitations. In many cases PSS research provides approaches that can be applied solely in one case which involves a large-scale company (Cf. Rolls-Royce; Xerox International; Mobility (Switzerland); Electrolux (Sweden); Eastern Energy (UK); Castrol Inc. (USA) and Parkersell (UK)). PSS affects firms differently based on company size [8]. An evaluation is needed to ensure practical relevance and to better understand the PSS paradigm in all company sizes. The literature published relating to PSS reveals that there is no specific research done in a manufacturing context that relates specifically to inventory control. However, in the business management field, there is a study that used inventory information for contract and fleet management in PSS. Also, for example, Datta and Roy [10] focus on inventory ordering patterns which is one of the factors related to delivery of performance-based service.

The interest in inventory control stems from real manufacturing issues. Inventory control is the process of tracking and tracing the quantity and location of inventory which is required by the company's procedures and frequencies and quantities in which components and materials are consumed. Inventory planning and control is therefore focused on questions such as when and how much new material should be ordered, produced or delivered? It is interdisciplinary and spans financial accounting as well as operational and logistics factors. There are three categories of stock: raw material stock (RMS) - incoming area; work-in-process stock (WIP) - assembly area and finished goods stock (FGS) - outgoing area. Inventory is expensive and can tie up company capital and resources, preventing these being used in other more productive ways. Inventory control is therefore crucial to many organisations because profitability is often linked to the effectiveness and accuracy of inventory control systems. Inventory control is required in a variety of contexts and is carried out by applying a number of theories, methodologies and tools that depend on the complexities and issues which arise in different organisations. Often studies in inventory control are conducted explicitly and are confidential for one organisation. Therefore, identifying the scope for the problem that is relevant and of interest is an essential pre-requisite in undertaking the analysis. Typically inventory control issues include inaccurate quantities, storage locations, pricing and identification, tracking and tracing inventory flows, capacity in managing inventory, damage inventory and inventory identification (cf. [11]; [12] and [13]). The solutions are often obtained by using methods such as probability theory, queuing theory, control theory, statistical inference, mathematical optimization, computer science and programming.

A case study is an extensive inquiry into a single phenomenon of interest that can answer questions like "what", "how" and "why", but does not provide answers for questions like "who" and "how many", [14]. The reason that case studies are best at addressing these certain types of questions is that case studies are typically concerned about the comprehensive understanding of phenomenon links in a natural setting and not the frequency of incidents or events [14]. Eisenhardt [15] refers to case study as "a research study which focuses on understanding the dynamics present within a single setting" (p. 534). Similarly, [16] has defined case study as: "an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used" (p.23). The case study is frequently used in many social science disciplines research [17] however, research in organizational and management research are increasingly using case studies [18]. Scapens [19] pointed out that the case studies are not only used as exploratory research where there are few theories of knowledge but also as illustrative case studies where the research tries to pictorialize new and maybe unique practices adopted by particular companies; experimental case studies where the research evaluates the implementations of new procedures and techniques in a company; and descriptive case studies where the objective of the case study is restricted to describing the company's current practice. In addition, [20] add another type of case study which is a case study arising by chance; the occurrence giving the researcher access and opportunity to evaluate the phenomenon. In the current research, an exploratory type of case study was selected.

II. Case Study

Company B is a medium sized company based in the United Kingdom. The company's principal business activities are design, manufacture and distribution of industrial electrical vehicles. It also offers second hand equipment, service packages, spare parts and driver training. In addition, the company offers vehicles specifically for event hire and short-term hire and these are all covered by full maintenance and on-site service packages. Company B's core business can be divided into three main markets:

i. Primary market: Selling the vehicle with a service package including an option of driver training.

ii. Secondary market: Renting the vehicles for event hire or short-term hire.

iii. Tertiary market: Remanufacturing and then selling second hand older vehicles

In the primary market, the customers have an option to select from the showcase of standard products or a bespoke product can be designed and manufactured to suit the customer's requirement. A service package is included with the product however; the package depends on the type of product. It provides working days service mobility and a team of engineers ready to get the vehicles repaired within 24 hours of the call in the case of breakdown. In addition, the company will provide familiarisation training to ensure the customer understands how to operate the vehicle safely. The service packages typically include maintenance 4 times a year for period of four or five years. Dependent on the type of vehicle, the average life cycle is typically between 4 and 7 years. Although some products are still bought outright, the Company B have identified an increasing trend in its primary market. The customers wish to buy under a form of leasing agreement for up to 7 years and are not interested in the buying the product at the end of this lease when the warranty and service agreements come to an end. As a result, such vehicles will then commonly be transferred to Company B's tertiary market. Company B's core business are summarised in Figure 1.

The secondary market of Company B's business is for hire. The company is very flexibile and can usually offer vehicles for last minute event hire. The vehicle will arrive fully serviced, clean, fully charged or fuelled and ready to work on arrival. The tertiary and final market targeted is for second-hand vehicles in Europe and this requires remanufacturing processes. Remanufacturing is a process of restructuring the value and function of the product so that it can be used again. When the vehicles that were initially sold to the primary market reach the end of its life cycle, an increasing number of vehicles are returned to Company B although some customers choose to manage the vehicle themselves. The vehicles returned to Company B will go through a number of phases in the remanufacturing process and will then be supported by six months warranty.

Company B has two main ICT support systems that support Before-Sales Department and After-Sales Care. The focus of the Before-Sales Department is to sell the products to the customer whilst the After-Sales Care focuses on supporting customers who have purchased a product or service. The ICT support systems in Before-Sales Department and After-Sales Care are integrated to some extent as they allow documents to be shared and prove real-time activity notifications. Therefore, the ICT support can make good use of the same resources and information in both the Before-Sales Department and After-Sales Care even though the two computing systems are separate and have different system interfaces. The ICT support system of the Before-Sales Department operation is a tool that helps Company B to reach business targets and financial goals not only in its primary market but also supports its secondary and tertiary markets. The system integrates internal and external resources, information and processes of its customer, production and transportation units. The integration process between the Before-Sales Department and other operational functions are summarised in Figure 2.

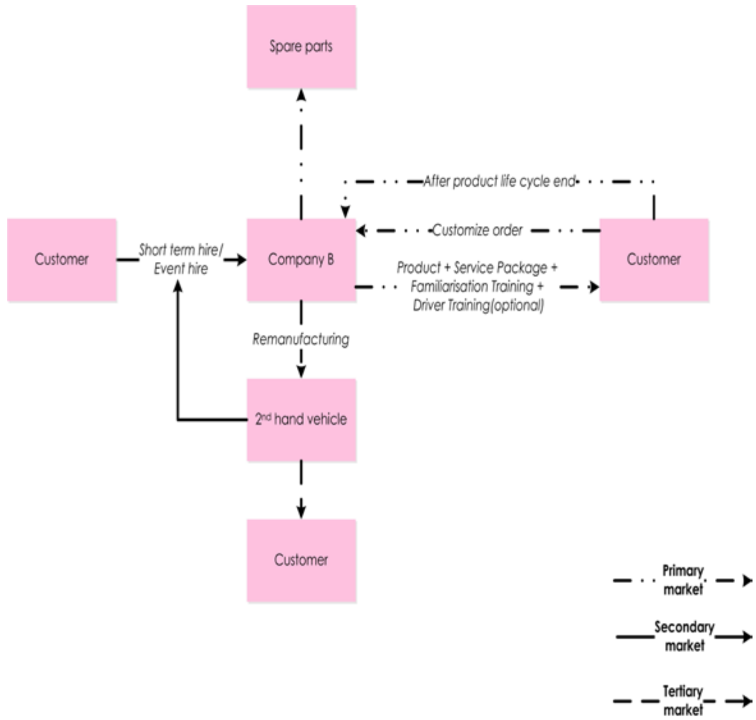

Fig. 1 Company B's core business elements

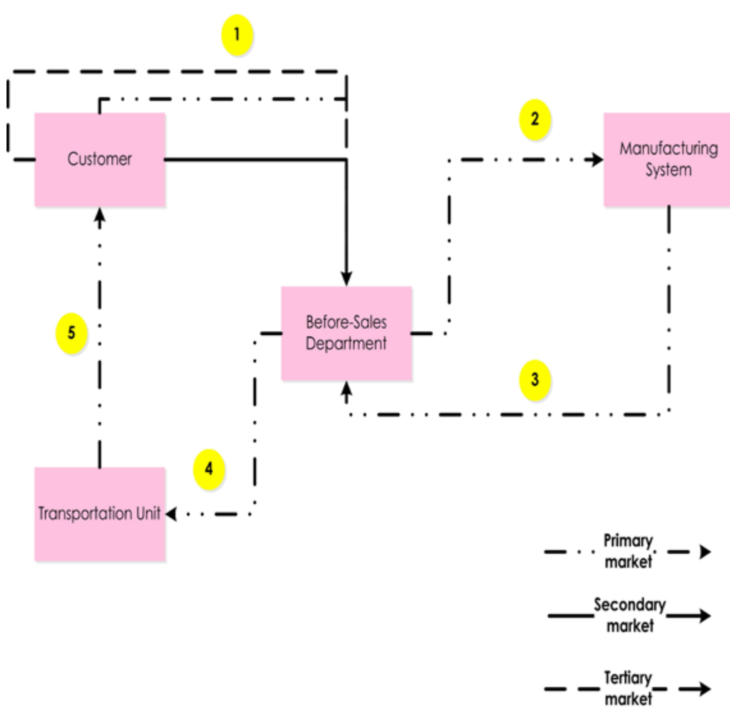

Fig. 2 Before-Sales Department integration elements

Table 1 provides a description of the main processes and information flows from the receipt of the customer order (flow 1) to the delivery of the product to the customer (flow 5).

TABLE 1. Before-Sales Department integration elements

Flow	Description of the main processes and information flows
1	Customer requests a quotation for their desired product including the technical details of the product, price of the product, contract terms and length, and payment terms to the Company B. The customer can select from the existing product range available or request a bespoke design. A discussion between the Before-Sales Department and customer may be held to produce a detailed specification. The customers can also obtain a quote for vehicle hire. There are also second-hand vehicles available to the customers (tertiary market).
2	The Before-Sales Department will issue relevant documentation including all the specifications that have been agreed with the customer. When a customer places an order, the order will be given a code. Then, the Before-Sales Department will extract and validate all the relevant information and input defaults of the product into the system. The system will then directly email all relevant people about the new order that has been placed. Next, the system will generate technical requirements for the manufacturing system to build the order.
3	The manufacture department receives information of what needs to be built and when it needs to be built by in order to deliver to the customer on time from the Before-Sales Department. The manufacturing system has five main sections: design, build, paint, finished good and quality inspection. Every vehicle will go through every section to become a complete product. Once the process of fabrication has been completed, the product will be tested and inspected to ensure the vehicle meets the specification and safety requirements. Once the manufactured product is ready, the manufacturing system forwards the notifications to the Before-Sales Department. The Before-Sales Department will update the system and an invoice will be generated and sent to the customer.
4	The Before-Sales Department will request the transportation unit to deliver the product to the customer. The transportation unit will then generate scheduling not only to deliver the product but also service products for other customers within the delivery area. This planning for servicing simultaneously with the delivery of new product is possible due to sharing of information between the Before-Sales Department and After-Sales Care.
5	The Before-Sales Department will update delivery date scheduled to the customer. The transportation unit will handle the delivery to the customer on the date given.

After-Sales Care is a planned or as required support system for service and maintenance of the product purchased by the customer including additional user training to operate the product. The After-Sales Care not only, covers the services for the primary market but also for the secondary market. For instance, planned service maintenance leads to optimisation of vehicle performance that in turn can reduce the vehicle breakdown rates. The support given to every customer, such as duration of service, maintenance policy and warranty is dependent on the details of the individual contract detailed signed when the customer purchased the product with the Before-Sales Department.

TABLE 2. After-Sales Care support system

Flow	Description of the elements
1	A customer calls Company B to receive help because the vehicle is not working. After-Sales Care will identify potential causes and the equipment sent to the breakdown is determined according to the scenarios explained by the customer.
2	After-Sales Care will update the system and generate the components needed to remedy the breakdown. It also will identify other customers at the breakdown customer location to visit for routine service and maintenance. During the period of contract, Company B will visit the site at no cost in order to repair or replace any component and remedy any fault of the vehicle.
3	The transportation unit will prepare all the components and tools to respond to the customer breakdown and other planned service and maintenance work in the area.

Company B provides two forms of manufacture, the production of new vehicle and remanufacture of old vehicles at the end of their lives. Production of a vehicle in Company B is broken down into several areas as illustrated in Figure 3. Company B's manufacturing system has five main sections: design, build, paint, finished product and quality inspection. The company will build an order to meet customer requirements. The design team will create the bespoke design or update a design of the vehicle with all the requirements and specifications as given by the Before-Sales Department. There are many aspects for consideration in designing the vehicle such as the outside and inside shape of the vehicle, colour, material used and interior layout. The design team not only need to create a design that functions effectively according to the customer requirements but that also meets the stringent health and safety requirements, maintaining performance and braking requirements. After approval of the technical design, the team generate the bill of the material, (BOM) needed to fabricate the vehicle. The BOM is a detailed list of materials, parts and the quantities needed to manufacture a product including the child parts such as screws, nuts and bolts. When, the inventory requirements have been established from the list of parts in BOM, the inventory system will then identify the stock availability and level, and determine which parts need to be ordered.

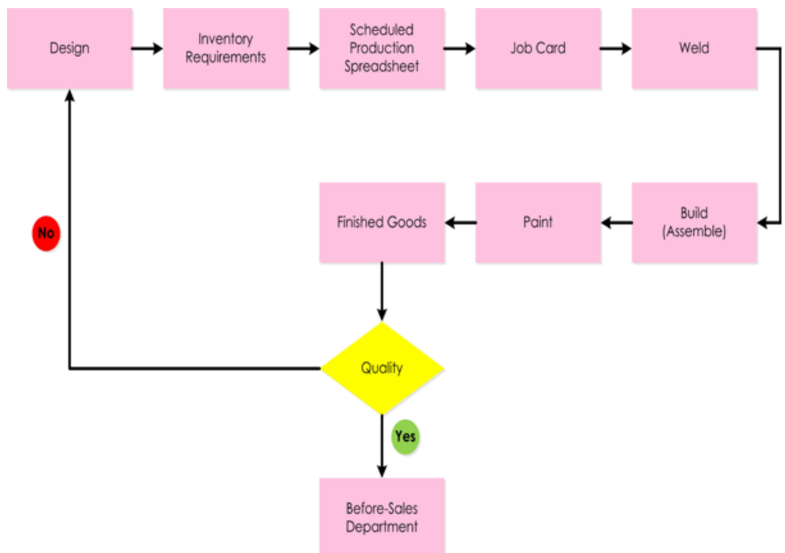

Fig. 3 Production flow

Scheduled production spreadsheets will be used to allocate the time needed for each labour section. Scheduled production spreadsheet is used to distribute the task planning by not only providing information on when to produce and how long to produce but also information on quantity of the product, equipment requirements and operator requirements. Next, a job card for every task in the production process flow to fabricate the vehicle will be published. The job card provides the procedures for completing a job on production methods from one process to another process in production line for instance the parts used and time taken to perform the work.

The labour in Company B's manufacturing system is divided into weld, build and paint. Welding is a process to join parts together at specific point. After parts go through the welding process, the welded parts and other components will all be passed on to the production line to be assembled. Lastly, the assembled parts will then move to paint. Before painting, the assembled parts need to be clean to remove dirt and oil. A traffic lights system is used in its production to flag the status and any problems in the production line; a red signal indicates the production line cannot go ahead, orange means the production can go ahead however, the production cannot finish and a green signal indicates that all is well and the job can proceed in the production line. If there is an error in the production line for instance a red light flashing, the assembly line will be stopped and the parts will not be sent to the next process until it is fixed. Once the process fabrication is completed it will run quality inspections to ensure the vehicle meets the specification and safety requirements.

The finished goods inspection will be conducted to ensure the vehicle standards and functions are met. Should there be any error or malfunction of vehicle the quality section will refer back to the design team, otherwise the production will close the job and inform the Before-Sales Department team that vehicle is ready to be delivered to the customer. The check sheet of the inspection will go to the Before-Sales Department. Company B collects its vehicle back at the end of the vehicle life if the customer does not want to keep it anymore. The vehicle can then be remanufactured. Remanufacturing is a process to repair, replace damaged parts, rebuild and refurbish a product that has been used. This will enable the product to perform at its original level of functionality and be resold into Company B's tertiary market.

The performance of a vehicle is dependent on the usage of the customer and the working environment. Company B provides three types of service; scheduled maintenance, breakdown and training. It has mobile service engineers who are trained to install and carry out maintenance and repairs at the customer's premises. 90% of calls are attended within 24 hours of receiving a call. For every vehicle purchased by the customer a service package is included. The service package included with the vehicle is dependent on the type of vehicle purchased and additional requirements needed from the customer. For the standard service, Company B provides a scheduled maintenance 4 times a year for a period of 4 to 5 years, which covers all aspects of a vehicle's running requirements. Notifications are given to the customer for every scheduled service and the service maintenance is performed once every quarter of the year

Vehicle breakdown is an uncertainty condition that can occur anytime and affect the operation of the customer's business. Company B provide 24 hours rapid response during working days to keep the vehicle running. When it receives a call from the customer about the breakdown, it will diagnose the possible causes and the components needed to repair the breakdown. Normally, when the customer called, they cannot specify the main causes or components of the breakdown; they just provide some indication of the breakdown to Company B. Through expertise and experience of the Company B service engineer, they will load the components in the service truck that might be needed to repair the vehicle.

Company B holds inventory of common components and the inventory is sorted by the type of components. Every vehicle has about 100 components. Inventory is not only used for production but also for the service, spare parts and remanufacture. Inventory is expensive and efforts are made to keep inventory levels to a minimum. Some items are not kept as inventory due to high costs or risks of obsolescence due to rapid changes in technology. Standard components are restocked when they reach the pre-determined minimum level. The maximum and minimum inventory levels are normally set depending of the type, price and supplier warranty of the components to make sure the life package inventory meets its aim. Although most inventory is kept in a central store, as Company B provides service and maintenance mobility, it needs to keep some inventory of vehicle components and tools in its trucks, in order to provide fast and efficient service and maintenance on customer sites.

Inventory stored includes components for the fabrication, service, spare parts and remanufacture of the vehicles. The Before-Sales Department controls the inventory for both sales and remanufactured vehicles. The After-Sales Care controls the inventory of service and spare parts although there are some exceptions that are dealt with on a case-by-case basis. The inventory-processing interface for both departments is different however; the source and information of inventory for both systems are the same. Parts of the system are automated using a stock control software package, while the remaining inventory is processed manually using Microsoft Excel. The integration process between the Before-Sales Department and After-Sales Care is also mostly automated.

III. Discussion

This paper highlights an ongoing case study undertaken with the aim of better understanding the inter-relationships between PSS and inventory control in manufacturing contexts. This case study aims to identify both similarities between the operation of inventory control for the product and service elements in PSS companies; and also differences resulting from the structure of the PSS in each company, manufacturing practices, organisational structure, the relevant ICT supports and other factors. The data obtained from this case study is qualitative. This case study does not use statistical methods and the cases are not intended as a statistically significant sample. The selected company described in the case study is a manufacturing SME in the United Kingdom that offers a product and also provides packages including services with their own products.

Collis and Hussey [21] identify the following stages in developing a case study:

- Selecting case: The case is selected which encompasses the phenomenon that the researcher interested and the case can be one or multiple. It is suggested that the researchers focus on the theoretical generalisations which means that the theory applied in the case study can be generalised to other and distinct cases providing opportunities to modify any theory.
- Preliminary investigations: The aim of this stage is to provide the researchers with the familiarisation of the case context. It is suggested that researchers reflect on their research paradigm and consider the purpose of their attributes to their research.
- Data stage: The researchers will be required to determine how, where and when to collect data. The evidence or data obtained can be qualitative, quantitative or both.
- The analysis stage: Analysis of the case study can be divided into 2; within case analysis; or cross-case analysis. The two analysis techniques provide different level and pattern of findings. Normally, the researchers who perform the within case analysis have deeper material information of cases that enable them to generate separate descriptions of the phenomenon to identify patterns. Researchers who perform the cross-case analysis may able to identify the similarities and differences of the cases to identify standard pattern.
- The report stage: There is no standard format in reporting cases however determining the appropriate structure to link all the material in cases are essential.

The current research followed this stage as the guide in developing the cases. However the analysis stage is not discussed in this paper. This case study is a combination of several data collection methods such as pilot interviews and transcription. One to one interviews were conducted in March 2015 and each interview conducted took about 1 hour to 2.5 hours. In general, the interview process is:

1. The interview was set up and conducted at the participant's company.

2. The participant received a set of questions to be asked through an e-mail prior to interview date.

3. Interviewed the participants. Additional questions were added to the set of questions that been sent to them for clarification and understanding of the case subject. Interviews that were conducted followed this standard pattern to obtain data. 4. The interviews ended with an opportunity for the interviewee to provide additional views about important issues but were not addressed directly by the interviewer.

In general, the conducted interviews have identified the following:

- There are potential issues for integration of support tools and accuracy of information as systems are half automated and half manual in Before-Sales Department and After-Sales Care.
- Every component of inventory has physical cost associated with it. The vehicle consists of different types of components such as black-box and electronic components with rapid changes in versions of technology, which are expensive. Therefore, it is challenging to maintain an optimal level of inventory at the same time as keeping the cost of inventory to the minimum.
- Management and storage of obsolete spare parts of inventory may be difficult prior to disposal through EBay.
- There are inevitable uncertainties in the service mobility provision, although this is managed very well and Company B is very flexible. Services are normally performed in area of the customer's premises.. There are uncertainties related to some of the parts that will be needed during the services and normally trucks are stocked with certain components and tools in anticipation of the service or maintenance that will be carried out. If the trucks do not carry the relevant components the travel cost and service time are increased. Thus, some duplication of inventory within the service trucks is necessary to provide flexibility, but is expensive.

In sum, this paper is in essence a preliminary discussion of an example of PSS in a manufacturing context, with a focus on inventory control. The richness of the input data provides a lively overview of the inventory control of PSS containing useful insights. This case study has shown that the inventory control of PSS is a complex business process, with significant interactions amongst participants (including operators, component suppliers and customers).

IV. Further Work

The case study has helped the researcher to understand and visualise the inter-dependencies between the various functions in inventory control of the products and services in PSS in manufacturing contexts. The richness of the data obtained from the interview has provided very useful knowledge with enriching and exciting insights. Information flows have been identified as the most common type of relationship and there is a perception that these flows are the main value carrier between the products and services inventory control. Future work will focus on trying to map this information into a generic model which initially will be used to test the proposed methodology. A holistic viewpoint and qualitative analysis approaches and systems thinking techniques will be used. Further research will be needed to verify that the generic model proposed is applicable in alternative scenarios and validate the developed generic model in this case study with other cases. Additionally, further research should be conducted to identify and provide practitioners with specific tools, methods, techniques and guidelines for creating improved inventory control in PSS in manufacturing contexts.

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